

ADHESIVE-LESS SUBSTRATE BONDING TO CARRIER PLATE

FIELD

[0001] Embodiments of the present principles generally relate to semiconductor processes used in packaging semiconductor devices.

BACKGROUND

[0002] A semiconductor substrate is processed to form structures on the substrate surface. The structures on a particular region of the substrate can be linked together to form a microcircuit. The substrate may have many different microcircuits constructed on the substrate's surface during processing. Once the substrate has finished being processed, the substrate is cut apart or singulated to separate the microcircuits into semiconductor 'chips' or dies. The substrate goes through numerous processes before the final chip is developed. Some of these processes include physical vapor deposition (PVD), lithography, and thermal curing.

[0003] The chips often contain complex circuitry which needs to interact with external components. The chip's internal circuitry is too minute to be connected directly to the external components. To overcome the external connection issues, lead outs are formed that are connected to the internal circuitry of a chip to a pad or solder ball that allows for external connections. The lead outs are formed in what is known as a redistribution layer during follow-on package processing of the semiconductor chips. Prior to these processes, the substrate undergoes a temporary bonding process. Typically, the temporary bonding process includes dispensing an adhesive in liquid form onto a glass carrier, followed by attaching a thin substrate film onto the adhesion surface before undergoing compression and thermal curing. Once the bonded substrate has completed the production processes, the substrate is released from the glass carrier via ultraviolet or laser methods that decompose the cured adhesive. However, the temporary bonding and de-bonding is expensive and time consuming. In addition, the techniques that use a temporary carrier also require additional processing steps that add to the costs and decrease the throughput for redistribution layer processes.

[0004] Accordingly, the inventors have provided improved methods and apparatus for bonding and de-bonding a thin substrate film to a carrier.

SUMMARY

[0005] Methods for bonding and de-bonding a thin substrate film to a carrier plate are provided herein. In some embodiments, a method of processing a semiconductor substrate includes applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material; applying a second layer to the polymer layer; forming one or more redistribution layers on the second layer; and separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.

[0006] In some embodiments, a method of forming a package includes applying an interface layer that is non-adhesive to a carrier plate formed of a dielectric material; forming one or more redistribution layers on the interface layer; coupling an integrated circuit to the one or more redistribution layers; and separating the one or more redistribution layers and the integrated circuit from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.

[0007] In some embodiments, a method of processing a semiconductor substrate includes applying an interface layer that is non-adhesive to a dielectric carrier plate, wherein the interface layer includes a first polymer layer and a second layer; forming one or more redistribution layers on the second layer; separating the second layer from the dielectric carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion; and removing at least one of the first polymer layer and the second layer from the one or more redistribution layers.

[0008] In some embodiments, a non-transitory computer-readable storage medium storing a program which causes a computer or processing chamber to execute a method of processing a semiconductor substrate includes: applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material; applying a second layer to the polymer layer; forming one or more redistribution layers on the second layer; and separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.

[0009] Other and further embodiments of the present disclosure are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Embodiments of the present disclosure, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative embodiments of the disclosure depicted in the appended drawings. However, the appended drawings illustrate only typical embodiments of the disclosure and are therefore not to be considered limiting of scope, for the disclosure may admit to other equally effective embodiments.

[0011] Figure 1 is a method of bonding and de-bonding a thin substrate film to a carrier plate in accordance with some embodiments of the present disclosure.

[0012] Figures 2A-2F depict stages of a process to bond and de-bond a thin substrate film to a carrier plate in accordance with some embodiments of the present disclosure.

[0013] Figures 3A-3F depict stages of a process to bond and de-bond a thin substrate film to a carrier plate in accordance with some embodiments of the present disclosure.

[0014] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. Elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0015] A semiconductor package is a metal, plastic, glass or ceramic casing containing one or more semiconductor electronic components. Fan Out Wafer Level Packaging (FOWLP) is an advanced semiconductor packaging adopted by the semiconductor industry. FOWLP packaging includes redistribution layers formed on a substrate. The substrate consists of a carrier plate bonded to a thin substrate film. In some embodiments, the carrier plate has an outer diameter of about 12 inches. Integrated circuit chips are then coupled to the one or more redistribution layers.

Then, the integrated circuit chips are encapsulated with an epoxy mold compound. These series of processes can be repeated again to complete an upper portion of the package assembly. Finally, the package assembly is released, or de-bonded, from the carrier plate via a variety of methods such as infrared exposure, magnetic induction heating, or electrostatic repulsion.

[0016] The inventors have found that a reversible bonding layer may beneficially join wafer films to a carrier such as a silicon carrier. In embodiments, a sacrificial layer may be used to join a thin wafer to a carrier such as a silicon carrier before releasing the bonded wafers to downstream processing.

[0017] Figure 1 is a method of bonding and de-bonding a thin substrate film to a carrier plate in accordance with some embodiments of the present disclosure. The method 100 starts at 102 by applying a non-adhesive interface layer to the carrier plate. In some embodiments, the non-adhesive interface layer does not comprise adhesive; however, may be bonded to the carrier plate as set forth below. The interface layer advantageously provides low outgas, high thermal stability, high chemical resistance, and high bonding strength. In some embodiments, as shown in Figures 2A-2B, an interface layer 218 includes a polymer layer 204 and a second layer 206. In some embodiments, the polymer layer 204 is non-adhesive and applied to a carrier plate 202. In some embodiments, the polymer layer 204 is not an adhesive layer and is characterized as non-adhesive; however, the non-adhesive layer may bond to a carrier plate 202 when applied to a carrier plate 202. In some embodiments, the carrier plate 202 is coated with the polymer layer 204 and then subsequently cured. In some embodiments, the carrier plate 202 is formed of a dielectric material. In some embodiments, the carrier plate 202 comprises silicon. In some embodiments, the polymer layer 204 comprises poly-dimethylsiloxane (PDMS), or the like, doped with nanoparticles. The nanoparticles are configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure. In some embodiments, the second layer 206 is deposited on the polymer layer 204. In some embodiments, the second layer 206 is a substantially pure or pure poly-dimethylsiloxane (PDMS) layer.

[0018] In some embodiments, as shown in Figures 3A-3B, an interface layer 318 includes a polymer layer 304 and a second layer 306. In some embodiments, the polymer layer 304 is non-adhesive and applied to a carrier plate 302. In some embodiments, the polymer layer 304 is not an adhesive layer and is characterized as non-adhesive; however, the non-adhesive layer is, in some embodiments, configured to bond to a carrier plate 302 when applied to a carrier plate 302. In some embodiments, the carrier plate 302 is configured as an electrostatic chuck including electrodes such as a first electrode 320 and a second electrode 330 embedded in the carrier plate 302. In some embodiments, the carrier plate 302 comprises a ceramic material. In some embodiments, the polymer layer 304 comprises a semi-electrically conductive polymer film. In some embodiments, the second layer 306 is formed of a conductive material. In some embodiments, the second layer 306 is a copper layer. The polymer layer 304 advantageously helps to bond the second layer 306 to the carrier plate 302. In operation, the first electrode 320 and the second electrode 330 of the carrier plate 302 are charged to induce an electrostatic attraction force between the carrier plate 302 and the second layer 306. The charges of the first electrode 320 and the second electrode 330 have opposite polarities to electrostatically clamp, or bond, the second layer 306 to the carrier plate 302. For example, the first electrode 320 may have a positive polarity while the second electrode 330 has a negative polarity.

[0019] Referring to Figure 1, in some embodiments, the method continues at 104 by forming one or more redistribution layers on the interface layer 218. In some embodiments, as shown in Figure 2C, one or more redistribution layers 208 are formed on the second layer 206. In some embodiments, integrated circuit chips 210 are coupled to the one or more redistribution layers 208. The integrated circuit chips 210 are encapsulated with an epoxy mold compound 212. In some embodiments, as shown in Figure 3C, one or more redistribution layers 308 are formed on the second layer 306. In some embodiments, integrated circuit chips 310 are coupled to the one or more redistribution layers 308. The integrated circuit chips 310 are encapsulated with an epoxy mold compound 312.

[0020] In some embodiments, the method continues at 106 by separating the second layer from the carrier plate via at least one of magnetic induction heating,

infrared exposure, or electrostatic repulsion. In some embodiments, the method continues at 106 by separating the interface layer including the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion. In some embodiments, as shown in Figure 2D, a magnetic field 214 is applied to the interface layer 218. The magnetic field 214 may be generated by a permanent magnet, an electromagnet, or the like. The magnetic field 214 is advantageously localized to target heating of nanoparticles that are embedded in the polymer layer 204. The magnetic field 214 is configured to not thermally impact the one or more redistribution layers 208. In some embodiments, the nanoparticles are configured to generate heat when the nanoparticles are exposed to magnetic induction heating. In some embodiments, as shown in Figure 2E, the heating of the nanoparticles separates the second layer 206 from the polymer layer 204 and the carrier plate 202. Accordingly, in some embodiments, bonds between the second layer 206 and the polymer layer 204 may be characterized as temporary or reversible. In some embodiments, the second layer 206 is exposed to infrared radiation to heat the nanoparticles to separate the second layer 206 from the polymer layer 204 and the carrier plate 202.

[0021] In some embodiments, as shown in Figures 3D-3E, the first electrode 320 and the second electrode 330 of the carrier plate 302 are charged to induce an electrostatic repulsion force between the carrier plate 302 and the second layer 306. The charges of the first electrode 320 and the second electrode 330 have the same polarity as the charges of the second layer 306 to separate, or de-bond, the second layer 306 from the carrier plate 302. For example, the first electrode 320 and the second electrode 330 may both have a positive. In some embodiments, heat is applied to the interface layer 318 to enhance the de-bonding process.

[0022] Referring to Figure 1, in some embodiments, the method 100 continues at 108 by removing any remaining material of the interface layer from the one or more redistribution layers. In some embodiments, as shown in 2F, the second layer 206 is removed from the one or more redistribution layer 208. In some embodiments, the second layer 206 may be removed by peeling. In some embodiments, the second layer 206 may be removed via a chemical process. In some embodiments, as shown in 3F, the polymer layer 304 is removed from the one or more

redistribution layer 308. In some embodiments, the polymer layer 304 may be removed by peeling. In some embodiments, the polymer layer 304 may be removed via a chemical process.

[0023] In some embodiments, the present disclosure relates to a method of processing a semiconductor substrate, including: applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material; applying a second layer to the polymer layer; forming one or more redistribution layers on the second layer; and separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion, wherein the carrier plate is configured as a electrostatic chuck including electrodes embedded in the carrier plate and the polymer layer includes a semi-electrically conductive polymer film, wherein the method further includes inducing an electrostatic attraction force between the carrier plate and the second layer prior to forming the one or more redistribution layers. In some embodiments, the second layer is a copper layer. In some embodiments, the method further includes storing charges having opposite polarities in the electrodes to electrostatically clamp the second layer to the carrier plate prior to forming the one or more redistribution layers. In some embodiments, methods further include applying a charge having the same polarity to the electrodes and to the second layer to separate the second layer from the carrier plate. In some embodiments, both the polymer layer and the second layer include polydimethylsiloxane (PDMS). In some embodiments, the polymer layer includes polydimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure. In some embodiments, the carrier plate comprises silicon.

[0024] In some embodiments, the present disclosure relates to a method of processing a semiconductor substrate, including: applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material; applying a second layer to the polymer layer; forming one or more redistribution layers on the second layer; and separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion, wherein the polymer layer includes polydimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic

induction heating or infrared exposure, wherein the second layer is a substantially pure poly-dimethylsiloxane (PDMS) layer, and wherein the second layer is separated from the polymer layer and the carrier plate via at least one of magnetic induction heating or infrared exposure to heat the nanoparticles.

[0025] In some embodiments, the present disclosure relates to a non-transitory computer-readable storage medium storing a program which causes a computer or processing chamber to execute: a method of processing a semiconductor substrate in accordance with the present disclosure such as including: applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material; applying a second layer to the polymer layer; forming one or more redistribution layers on the second layer; and separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.

[0026] In some embodiments, the present disclosure relates to a non-transitory computer-readable storage medium storing a program which causes a computer or processing chamber to execute: a method of forming a package including: applying an interface layer that is non-adhesive to a carrier plate formed of a dielectric material; forming one or more redistribution layers on the interface layer; coupling an integrated circuit to the one or more redistribution layers; and separating the one or more redistribution layers and the integrated circuit from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.

[0027] In some embodiments, the present disclosure relates to a method of processing a semiconductor substrate, including: applying an interface layer that is non-adhesive to a dielectric carrier plate, wherein the interface layer includes a first polymer layer and a second layer; forming one or more redistribution layers on the second layer; separating the second layer from the dielectric carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion; and removing at least one of the first polymer layer and the second layer from the one or more redistribution layers. In some embodiments, the first polymer layer includes poly-dimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure. In some embodiments, the dielectric carrier plate is configured as an

electrostatic chuck including electrodes embedded in the dielectric carrier plate and the interface layer comprises a semi-electrically conductive polymer film, and further includes inducing an electrostatic attraction force between the dielectric carrier plate and the second layer prior to forming the one or more redistribution layers.

[0028] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof.

Claims:

1. A method of processing a semiconductor substrate, comprising:
applying a polymer layer that is non-adhesive to a carrier plate formed of a dielectric material;
applying a second layer to the polymer layer;
forming one or more redistribution layers on the second layer; and
separating the second layer from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.
2. The method of claim 1, wherein the carrier plate is configured as an electrostatic chuck including electrodes embedded in the carrier plate and the polymer layer comprises a semi-electrically conductive polymer film, and further comprising inducing an electrostatic attraction force between the carrier plate and the second layer prior to forming the one or more redistribution layers.
3. The method of claim 2, wherein the second layer is a copper layer.
4. The method of claims 2 or 3, further comprising storing charges having opposite polarities in the electrodes to electrostatically clamp the second layer to the carrier plate prior to forming the one or more redistribution layers.
5. The method of claim 4, further comprising applying a charge having the same polarity to the electrodes and to the second layer to separate the second layer from the carrier plate.
6. The method of any of claims 1-5, wherein both the polymer layer and the second layer comprises poly-dimethylsiloxane (PDMS).
7. The method of claim 6, wherein the polymer layer comprises poly-dimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure.

8. The method of any of claims 1-7, wherein the polymer layer comprises poly-dimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure, wherein the second layer is a substantially pure poly-dimethylsiloxane (PDMS) layer, and wherein the second layer is separated from the polymer layer and the carrier plate via at least one of magnetic induction heating or infrared exposure to heat the nanoparticles.
9. A method of forming a package comprising:
applying an interface layer that is non-adhesive to a carrier plate formed of a dielectric material;
forming one or more redistribution layers on the interface layer;
coupling an integrated circuit to the one or more redistribution layers; and
separating the one or more redistribution layers and the integrated circuit from the carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion.
10. The method of claim 9, wherein applying an interface layer to the carrier plate comprises applying a first polymer layer to the carrier plate and applying a second layer to the first polymer layer.
11. The method of claim 10, wherein the second layer is a copper layer.
12. The method of claims 10 or 11, wherein both the first polymer layer and the second layer comprises poly-dimethylsiloxane (PDMS).
13. The method of claim 12, wherein the first polymer layer comprises poly-dimethylsiloxane (PDMS) doped with nanoparticles configured to generate heat when the nanoparticles are exposed to magnetic induction heating or infrared exposure.

14. The method of claim 10, wherein the carrier plate is configured as an electrostatic chuck including electrodes embedded in the carrier plate and the interface layer comprises a semi-electrically conductive polymer film, and further comprising inducing an electrostatic attraction force between the carrier plate and the interface layer prior to forming the one or more redistribution layers.
15. A method of processing a semiconductor substrate, comprising:
applying an interface layer that is non-adhesive to a dielectric carrier plate, wherein the interface layer includes a first polymer layer and a second layer;
forming one or more redistribution layers on the second layer;
separating the second layer from the dielectric carrier plate via at least one of magnetic induction heating, infrared exposure, or electrostatic repulsion; and
removing at least one of the first polymer layer and the second layer from the one or more redistribution layers.